RECOVERY PLAN

Ruth's Golden Aster

U.S. Fish and Wildlife Service

RECOVERY PLAN

for

Ruth's Golden Aster (*Pityopsis ruthii* [Small] Small)

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Literature citations should read as follows:

U.S. Fish and Wildlife Service. 1990. Ruth's Golden Aster Recovery Plan. Atlanta, GA. 33 pp.

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EXECUTIVE SUMMARY

CURRENT STATUS: Ruth's golden aster is currently listed as an endangered species by the State of Tennessee and the U.S. Fish and Wildlife Service. It is known from two populations in Polk County, Tennessee. The Ocoee River population supports about 600 individuals, while the Hiwassee population supports 10,000 to 15,000 individuals.

HABITAT REQUIREMENTS AND LIMITING FACTORS: This species grows only in the cracks or crevices found in phyllite or graywacke boulders along the banks of or within the Ocoee and Hiwassee Rivers. Water flow regimes on both rivers have been altered by the construction of dams for power generation. This may have resulted in increased competition from other vegetation on the Hiwassee. Current recreational water use may result in water levels much higher than normal during the growing season on the Ocoee. Trampling by hikers, fishermen, and other recreational users of its habitat is also adversely affecting the species to some degree.

RECOVERY OBJECTIVES: To downlist and eventually delist the species.

RECOVERY CRITERIA: Viable, self-sustaining populations on the Ocoee and Hiwassee Rivers.

ACTIONS NEEDED: (1) Determine reproductive biology of the species, (2) determine habitat requirements, (3) obtain life history information on the species, (4) define what constitutes a viable population, and (5) determine and implement management actions needed to ensure the continued existence of self-sustaining populations of the species on the Hiwassee and Ocoee Rivers.

COSTS (1,000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Total
1993	10.0	23.0	13.0	4.0	37.5	87.5
1994	6.0	6.0	5.0	2.0	13.0	32.0
1995	4.0	3.0	5.0	2.0	13.0	27.0
1996		2.0	2.0	2.0	3.0	9.0
1997		2.0	2.0		3.0	7.0
TOTAL:	20.0	36.0	27.0	10.0	69.5	162.5

DATE OF RECOVERY: In 1998, provided required recovery funds are available and needed recovery activities are accomplished.

PART I

INTRODUCTION

Ruth's golden aster (Pityopsis ruthii [Small] Small, Asteraceae) is a rare plant endemic to short stretches of the Hiwassee and Ocoee Rivers in Polk County, Tennessee. Because of its limited distribution and its vulnerability to a variety of threats, it was listed by the U.S. Fish and Wildlife Service (Service) as endangered on July 18, 1985 (U.S. Department of the Interior 1985), effective August 19, 1985. Ruth's golden aster also is listed as endangered by the State of Tennessee under the provisions of "The Rare Plant Protection and Conservation Act" (Public Acts of 1985, Chapter 242).

Systematics

The first specimens of *Pityopsis ruthii* were collected in the Hiwassee River Gorge by Albert Ruth of Knoxville, Tennessee, during the period from 1894 to 1902 (Bowers 1972a). Unaware of any subsequent collections, Harms (1969) speculated that the species might be extinct. However, in 1970 Bowers (1972a) confirmed the species to be extant. He also noted a previously unreported collection of the species on the Hiwassee made by W. J. Dress in September of 1953. Fourteen years later, A. J. White (1977, 1978) discovered a population of the species on the Ocoee River. Searches by White and others (Wofford and Smith 1980, Collins and Gunn 1987) on the Tellico, Conasauga, and Jacks Rivers have failed to yield populations on any other river systems.

Past taxonomic treatments of Ruth's golden aster, and golden asters in general, have involved frequent shifting of species among genera. Small (1897) described the species as *Chrysopsis ruthii* but subsequently transferred it to the genus *Pityopsis* (Small 1933), a genus characterized as those golden asters with graminiform (grass-like) leaves. This concept was rejected by Fernald (1942) who described the recognition of *Pityopsis* as "hardly worthwhile" and retained the species in *Chrysopsis*. Later, Shinners (1951) included *Chrysopsis* in his concept of the genus *Heterotheca*. His treatment generally was accepted by Harms (1969), who published the combination *Heterotheca ruthii*, and by Bowers (1972b) and Cronquist (1980). Dress (1953), in his study of the eastern *Chrysopsis*, continued to follow Small's 1933 nomenclature (except in the case of the *Pityopsis graminifolia* complex). Semple (1977), Semple *et al*. (1980), and Semple and Bowers (1985) reaffirmed *Heterotheca*, *Chrysopsis*, and *Pityopsis* as distinct genera. Semple's work is widely accepted, and Ruth's golden aster will be referred to here as *Pityopsis ruthii* (Small) Small. It is instructive to note that no student of the genus has questioned the validity of the species, only the proper generic designation.

Description

Pityopsis ruthii is an herbaceous, tufted perennial with slender stoloniferous rhizomes. The few to several stems are 1 to 3 decimeters (dm) tall, erect to ascending or decumbent, stiffish, and terete. They are silvery-sericious (or partly glabrate) throughout, except for the stipitate glandular peduncles and involucres and the bases of the stems, which retain the brownish, scaly, old leaf bases. The silvery-white appearance is produced by numerous long, appressed hairs that are admixed above on the stem with short, spreading, peg-like glandular hairs. Branches are few to several, upwardly arching, and originating from the mid-stem upward. Leaves are numerous, chiefly cauline, overlapping in tight spirals, ascending or erect, linear, lance-linear or gladiate, mostly 2 to 6 centimeters (cm) long by 2 to 4 millimeters (mm) wide. They are narrowly acute or acuminate and entire; the bases are attenuate and clasping, with surfaces silvered with long, appressed hairs. The lower cauline leaves generally are soon deciduous. Basal leaves, when present, often are tufted but not enlarged. The inflorescence comprises one to several heads in a cyme. The peduncles are usually longer than the heads, upwardly arching, and copiously spreading-glandular-hairy. The heads are broadly campanulate, about 1 cm high (from the base to tip of disc), and 1 cm broad across the top of the involucre. The involucre is 6-10 mm high. The involucral bracts are lance-linear; attenuate-tipped; loosely overlapping in several series; all green with broad, pale, ciliate margins; and the backs are sessile-glandular. Innermost bracts are 7-8 mm long, while the outermost are shorter. There are 8-15 ray florets with a pappus of numerous capillary, dull-white bristles about 4-5 mm long. Corollas are yellow with flattish spreading claws about 3 mm long. Blades are linear-elliptic or oblanceolate, 6-10 mm long. Disc florets are numerous, with pappus similar to that of the rays. Their corollas are yellow, tubular, and about 5 mm long, with a slightly expanded throat. The five corolla lobes are triangular and erect or slightly spreading. Flowering occurs from July to frost, peaking in September. The pale brown achenes are lance-fusiform or linear-fusiform, 3.5 to 4.0 mm long, slightly ribbed, slightly compressed, silvery-pubescent proximally and smooth distally, being narrow at the apex (Cronquist 1980, Kral 1983).

Pityopsis ruthii can be distinguished from other members of the genus by a combination of characteristics, including the comparatively short, overlapping leaves (which show little gradation in size from the base to the apex of the stem), together with the glandular nature of the pubescence of the peduncles, inflorescence branches, and involucral bracts (Kral 1983). P. ruthii can also be distinguished by its habitat preference. P. ruthii is restricted to exposed boulders along the river, while the sympatric population of P. graminifolia grows in adjacent woodlands (Bowers 1972a, Collins and Gunn 1986).

Distribution

The known distribution of Ruth's golden aster is limited to the Hiwassee and Ocoee Rivers in Polk County in the southeastern corner of Tennessee. The original collections of Pityopsis ruthii made by Albert Ruth were from the Hiwassee River Gorge near the now abandoned town of McFarland (Bowers 1972a). Small (1897) and Gattinger (1901) originally published its distribution only as the Hiwassee Valley. White (1977) later determined that P. ruthii inhabited a 3-mile section of that river, beginning 1.2 miles above the Smith Creek Powerhouse and extending to a point 4.2 miles upstream, just above the mouth of Wolf Creek. He also discovered the population on the Ocoee River (White 1977, 1978). The plants discovered by White extended from 0.1 mile above the Ocoee No. 2 Powerhouse and to 1.1 miles upstream. An additional subpopulation was later discovered on the Ocoee (Wofford and Smith 1980) approximately 3.3 miles above the powerhouse at river mile 23, near the mouth of Short Creek.

The distribution of P. ruthii coincides with the exposure of a band of Precambrian phyllite belonging to the Walden Creek and Great Smoky groups (White 1977, Hardeman 1966). This phyllite also provides the virtually exclusive habitat for P. ruthii, although the recently discovered subpopulation at river mile 23 on the Ocoee was found to occur on a Precambrian graywacke (Collins and Gunn 1987). On both rivers, the phyllite rock, which serves as habitat for P. ruthii, generally is exposed between the river channel and adjacent forested slopes of the river gorges. It also occasionally occurs as islands in the middle of the stream. Plants usually are found growing in the small pockets of soil that accumulate in the cracks and crevices of phyllite boulders exposed to sunlight most of the day.

Ecology and Life History

Analyses, both of soil in which P. ruthii plants grow and of the phyllite rock as well, indicate neither the absence nor the presence of any unusual nutrient, nor are there any unusual mineral or chemical abundances or deficiencies (White 1977). This is corroborated by Farmer (1977), who grew a number of individuals to maturity under standard greenhouse conditions. Farmer also demonstrated that P. ruthii seeds have no special germination requirements. The plants he established grew in beds for a number of years at a Tennessee Valley Authority (TVA) nursery, but they are no longer extant (Collins, Tennessee Valley Authority, personal communication, 1988).

One reason for the restriction of P. ruthii to exposed phyllite may be its inability to compete with other more vigorously growing associates (such as Solidago arguta ssp. caroliniana and Aster dumosus) in richer sites (White 1977). However, inability to compete with other species may not entirely account for its restricted occurrence. It is noted by Haggard and Halback (1985) that many areas along the Hiwassee, which seemed to provide very good habitat for P. ruthii, were unoccupied by the species. Likewise, P. ruthii was found in some locations that did not seem suited to it. This has been observed by others as well (Collins and Gunn 1986).

The reason for the limited geographic range of P. ruthii (i.e., on only two rivers) is less well understood. The same band of phyllite exposed by the Hiwassee and Ocoee Rivers also appears on the Tellico River to the northeast and on the Conasauga and Jacks Rivers to the south. White (1977) reports that P. ruthii will not occur where light intensity is less than 50 percent of full sunlight. The gorges of these three rivers are much narrower than those of the Hiwassee and Ocoee. Consequently, less sunlight reaches the boulders along these other rivers. Pityopsis ruthii's apparent need for sunlight, and the possible lack of sunlight in sufficient amounts on any of these three rivers, could account for the absence of P. ruthii on them (White 1977). The role that seed dispersal plays in this puzzling distribution is yet to be investigated.

Pityopsis ruthii is strongly associated with Liatris microcephala, which usually is found wherever P. ruthii occurs (Collins and Gunn 1986, 1987). Other associates include Andropogon ternarius, Aster dumosus, A. linariifolius, and Solidago arguta ssp. caroliniana (Bowers 1972a, White 1977). White (1977) terms A. dumosus, L. microcephala, and S. arguta ssp. caroliniana "secondary invaders," which, in the absence of natural flooding, gradually are outcompeting P. ruthii for habitat as soil depths increase. His greenhouse studies demonstrated the inability of P. ruthii to compete with A. dumosus and S. arguta ssp. caroliniana. However, he did not involve L. microcephala in any of those studies. Given the diminutive stature of L. microcephala (similar to P. ruthii or smaller), and its apparently preferred habitat (the shallowest soils in the rock crevices, the same as P. ruthii), it is likely that it too would be outcompeted by A. dumosus and S. arguta ssp. caroliniana under similar conditions. Liatris microcephala should not be considered a secondary invader; while further study is necessary, P. ruthii and L. microcephala probably are codominants on the phyllite, with neither being capable of forcing out the other under current conditions.

In addition to soil analysis and competition studies, White (1977) studied the effects of several other biotic and abiotic influences on the growth of P. ruthii. These include incident light intensity; rock surface, soil, leaf and air temperatures; and drought stress, both in the field and in the greenhouse. These studies demonstrated the ability of P. ruthii, over some of its competitors, to survive the extremes of the harsh environment in which it is found. In addition, he concluded that, where it occurs naturally, P. ruthii grows under suboptimal conditions. Indeed, plants grown under conditions that essentially eliminated drought and competition became conspicuously more vigorous and robust than specimens observed in the wild (Farmer 1977).

Reproduction in natural populations is attributed to stem regeneration or tillering of the subaerial root-rhizome crown (Wofford and Smith 1980). This agrees with White (1977), who stated that the chief method of reproduction is by existing rhizomes. White observed no seedlings in the field and concluded that P. ruthii has difficulty becoming established on the phyllite boulders. His comparison of plants from the Hiwassee River population with those grown for his greenhouse studies showed an average of 50 achenes and 58 achenes per flowering head, respectively. Typically, 18 percent of those achenes from the wild population were filled (i.e., viable) compared to 19 percent from the greenhouse populations. Although White (1977) presented no figures on percentage germination of the filled achenes he sowed during his greenhouse study, he indicated that 62 percent of the P. ruthii seedlings resulting from the 960 filled achenes sown survived their first 3 weeks.

It is suggested that a combination of wind and nonselective foraging by insects could account for the low percentage of filled achenes (Wofford and Smith 1980). No studies of pollinators or of pollination in P. ruthii have been performed. However, in the field, Bowers (1972a) noted several kinds of bees visiting the flowers of various members of the section Pityopsis (including P. ruthii), and in the greenhouse he observed occasional visits by flies to the flowers of the same species. He determined that members of the section Pityopsis are obligate outcrossers and that self-fertilization and apomixis seldom, if ever, occur. He also concluded that wind is of little importance in pollination. White (1977), while collecting soil samples in the field, observed numerous ant colonies sharing the same crevices with P. ruthii. He suggested there may be a relationship between the presence of the ants and the establishment of P. ruthii but made no further investigation of this potential relationship.

No study of fruit dispersal has been made, but the pappus is disposed to dissemination by wind. According to Wofford and Smith (1980), dispersal also is achieved by water. They regarded effective dispersal as rare, based on the paucity of observations of seedlings in nature, but provided no supportive data.

Production of low numbers of viable seeds could easily contribute to difficulties in the establishment of new plants. Ineffective dispersal methods also could be a contributing factor. While Wofford and Smith (1980) stated that "age class determinations indicate only mature individuals are present," there was evidence that regeneration from seeds is occurring. In an ongoing study of P. ruthii, Collins and Gunn (1986) observed one subpopulation on the Hiwassee River comprising 1,149 individual plants. Relative to other subpopulations measured in 1986 and 1987, a greater preponderance of those plants were small and single-stemmed and were not located near enough other larger plants to have come from rhizomes. The same subpopulation was measured the next year (Collins and Gunn 1987), and 307 fewer individuals were found, perhaps the victims of stress from severe drought. Apparently many of the absent individuals were the small, single-stemmed plants recorded the prior year. It is possible that many of those plants were young seedlings, not yet vigorous enough to withstand the extreme conditions at the time. Furthermore, a great many more individuals not producing flowering heads were seen than were found by Wofford and Smith (1980).

The extent and significance of predation upon P. ruthii are not known. White (1977) observed predation by the larvae of three moth species on plants in the greenhouse. In the field, Collins and Gunn (1986) also have observed insect larvae apparently feeding on the achenes in the maturing heads of some plants.

Current Status

Pityopsis ruthii is known from two short stretches of the Hiwassee and Ocoee Rivers in southeastern Tennessee. The Ocoee River population is the smallest of the two. White (1977) stated that this population consisted of fewer than 500 individuals. Wofford and Smith (1980) estimated the combined number of individuals from both populations to be under 1,000--less than 500 on the Ocoee and somewhat greater than 500 on the Hiwassee.

More recent figures from Haggard and Halback (1985) revealed the total number of plants from both rivers to be several thousand individuals. They counted exactly 593 individuals on the Ocoee (this was feasible because of the small amount of habitat) and estimated a "substantial population" to be on the Hiwassee. More precise numbers were provided in their descriptions of various sites along the Hiwassee. During the initiation of their work on P. ruthii on the Hiwassee River, Collins and Gunn (1986) estimated the population there to comprise between 10,000 and 15,000 plants. Expanding their work in 1987, they counted a total of 631 plants on the Ocoee (Collins and Gunn 1987). Though slightly more than the previous count by Haggard and Halback, it is relatively close to their figure of 593. The increase is believed to reflect different counting methods rather than an actual increase of population size.

Threats

In the discussion of current threats to Pityopsis ruthii, the populations on the Hiwassee and Ocoee Rivers should be treated separately. Each population faces its own peculiar combination of threats.

Presently, the Hiwassee River population may be considered the most secure, both from the standpoint of its size and its receiving less impact from outside influences. The chief concern on the Hiwassee is the putative replacement of P. ruthii by more competitive herbaceous and woody species through succession. This succession allegedly is occurring because of a reduced water flow and a lower frequency of flooding than that which occurred historically. Both circumstances were brought about by the closing of the Appalachia Dam in 1943 and the diversion of its backwaters through a tunnel to the Smith Creek Powerhouse, thus causing the main flow to bypass the stretch of the Hiwassee inhabited by P. ruthii. Generally, the water now flowing through the bypassed portion of the Hiwassee comes from tributary streams, runoff from adjacent slopes, and rainfall directly over the river. In addition, water is infrequently released from the dam, such as in times of flooding. This may be beneficial, but its effects, if any, are not known.

Bowers (1972a) first reported this succession on the Hiwassee, calling Liatris microcephala, Andropogon ternarius, and Aster linariifolius associates of P. ruthii that eventually replace it as soil depths increase. Later successional stages include red maple, sweetgum, beech, and black willow. He also stated that it is "...conceivable that with additional soil build-up, competition may become intolerable for [P. ruthii] to survive," but that it is not known to him "...what effect the damming of the river and reduced flow does have on [P. ruthii]." White (1977) stated that he believes the normal periodic flooding that occurred prior to the closing of the dam scoured the phyllite rocks, removing some soil accumulation from their crevices. This enables P. ruthii to compete successfully in this habitat by making it unsuitable for other species. White (1977) demonstrated that P. ruthii competitors require greater soil depths to grow than does P. ruthii and indicated that potential habitat for P. ruthii is being utilized by its "secondary invaders," which, according to him, are "...continually taking over additional [P. ruthii] habitat." It was his belief that P. ruthii slowly is being displaced along the Hiwassee by other species and that the decline, under the conditions he saw, might not ever stabilize. Haggard and Halback (1985) also reported that P. ruthii apparently is declining on the Hiwassee as a result of encroachment by successional vegetation. They concluded that lack of flooding is the reason for it but, like White, provided no data to substantiate their conclusions.

Wofford and Smith (1980) commented on the previous work by Bowers (1972a) and White (1977) and acknowledged that the lack of normal flooding, as would have been present prior to the closing of the Appalachia Dam, could permit soil accumulation in P. ruthii habitat. This may allow encroachment of competitors and ultimately result in the displacement of P. ruthii. However, they declined to state that this indeed is taking place. Instead, they noted that no evidence of either expansion or decline of the species was found.

In contrast to the decline of P. ruthii, which he believed was occurring on the Hiwassee, White (1977) also stated that it is likely that P. ruthii at one time had increased its numbers there. The closing of the Appalachia Dam in 1943, with the subsequent drop in the water level, exposed additional phyllite boulders that P. ruthii then was able to colonize. Collins and Gunn (1986) stated that their estimate of the size of the Hiwassee River population is believed by them to represent a historic, or near-historic, high level, which resulted from the exposure of new habitat after the reduction of the water level. They also stated that they believed that any succession being permitted due to a lack of flooding may be occurring at a rate slower than that alluded to by White and others.

The idea is forwarded by several (Bowers 1972b, White 1977, Wofford and Smith 1980, Haggard and Halback 1985) that succession on the phyllite boulders is no longer kept in check because of a lack of what is termed "normal flooding." There apparently may be another factor that is responsible, at least partly, for maintaining the primary successional substrate on which P. ruthii occurs. Earlier discussion regarding the existence of seedlings pointed out that seedlings may have been encountered by Collins and Gunn (1986, 1987). Their observations in 1987 were made while east Tennessee was experiencing the third year of a severe drought. During the same period in which they gathered the data referred to previously, numerous other herbaceous and woody species were observed dead as well, apparently from stress caused by the drought. Dead plants generally were found on the phyllite boulder habitat at various spots along the Hiwassee and included numerous individuals of P. ruthii. Cyclic drought probably has played a role in maintaining the phyllite boulders in a "pioneer stage." The extent of that role is not known, but further investigation is needed and warranted.

Other threats to P. ruthii on the Hiwassee appear to be minor. The U.S. Forest Service (USFS), owner of the land on which P. ruthii occurs, has no plans to timber or otherwise alter the section of the river gorge containing the species. There is occasional trampling of plants by fishermen or hikers, but since the population is accessible by foot only, impact of this trampling has been minor. Farmer (1977) suggested that because of its numerous bright yellow inflorescences and its dense silvery-green foliage, P. ruthii has potential as a horticultural plant. Therefore, exploitation by horticultural collectors may pose a threat (Wofford and Smith 1980), but the limited access provides some protection. Such a threat is more serious on the Ocoee because of the lower numbers of individuals and greater accessibility.

White (1977) noted that two acid spills into the Hiwassee, the result of train derailments upstream, occurred during the course of his research. Each time, water was released from the Appalachia Dam to dilute the acid and to flush the river. One release raised the level of the river sufficiently to temporarily submerge some P. ruthii plants. In flower at the time, most of these individuals' "...reproductive efforts...were thwarted," apparently as a result of contact with the acid. Although White (1977) provided no data regarding the effects of these spills, it is reasonable to assume that any contact of caustic chemicals with these plants could be very damaging.

The Ocoee River population of *P. ruthii* should not be considered secure. Its low numbers, in contrast to the Hiwassee population, are the product of a variety of influences, and current threats to it are varied and complex. An obvious reason for the small size of the population is the lack of suitable habitat. The Ocoee apparently has always had less suitable habitat than the Hiwassee. However, White (1977) speculated that construction of a wagon road on the north bank of the river in the early 1850s, and the subsequent construction of U.S. Route 64 on the same site, destroyed much suitable, and probably occupied, habitat. It is interesting to note that most occurrences of *P. ruthii* on the Ocoee River are either on the south bank or in the center of the stream (White 1977, Haggard and Halback 1985).

Like the Hiwassee, the Ocoee River has been dammed. Ocoee No. 1 Dam, downstream of the population of *P. ruthii*, created Parksville Lake, whose backwaters reach almost to the Ocoee No. 2 Powerhouse. Known locations for *P. ruthii* on the Ocoee begin 0.1 mile upstream of that powerhouse. It is possible that suitable habitat containing *P. ruthii* was inundated with the formation of the Parksville Reservoir. However, since the species was not known from the Ocoee until very recently, its existence in locations further downstream can only be conjectured. Likewise, suitable habitat with *P. ruthii* may have been flooded after the completion of the Ocoee No. 2 Dam, upstream between river miles 24 and 25. This is less likely, though, since the nearest known location of *P. ruthii* to the No. 2 Dam occurs approximately 1.5 miles downstream at river mile 23.

As on the Hiwassee, the flow of the Ocoee is diverted. Water is directed through a flume around the river segment occupied by *P. ruthii*, usually leaving flow in the channel virtually nonexistent when power is being generated. Diversion of the river began in about 1912, when the dam and flume were constructed, and continued until 1976, when the flume was closed because its deteriorated condition made it a safety hazard (Loney 1984). During the period prior to 1976, water was released through the dam infrequently, usually during periods of scheduled maintenance. Full water flow through the natural channel occurred from 1976 until the completion of a new flume and the resumption of water diversion for power generation in the fall of 1983. During this 7-year hiatus from altered flow, the Ocoee River rapidly became a popular location for white-water recreation. When it was learned that TVA (the agency maintaining and operating the dam and flume) would resume power generation, both the commercial and private recreational interests protested. They felt that diversion of water once again into the flume would cause a potential loss of use of the area for white-water sports. The controversy ultimately was settled with a compromise that provided for power generation on weekdays and releases from the Ocoee No. 2 Dam for recreation on weekends and holidays (Loney 1984). In addition, there are occasional releases during weekdays to flush silt from behind the No. 2 Dam. This is the general manner in which the river has been managed since March 1984, and it probably will continue for an indefinite period.

Pityopsis ruthii on the Ocoee River has been subjected to a variety of water flow regimes during the past 75 years. How the species has been affected by this is not known. Present management of the river provides for scheduled releases on weekends and holidays during the spring from late March through May and in the fall from September through early November. In addition, releases during June, July, and August take place 5 days per week and on holidays (Loney 1984). During a release, some individuals of *P. ruthii* are subjected to temporary inundation that might not occur during the same months under a natural flow. During the period from July through October, it has been determined that the natural flow through the Ocoee below the No. 2 Dam averages about 700 cubic feet per second (cfs). Current releases for recreation are providing an average flow of 1,200 cfs (Loney 1984). No documentation exists that current Ocoee River water management has any effect upon *P. ruthii*.

Management of the Ocoee River for white-water recreation has produced an additional potential threat. Visitation to the river by rafters, canoers, and kayakers has provided increased opportunity for human contact with *P. ruthii*. In 1984, a total of 78,700 people floated the Ocoee River. In 1987, the number was 128,507, an increase of nearly 50,000 individuals in only 4 years (Allen, Tennessee Department of Environment and Conservation, personal communication, 1988).

The recently discovered subpopulation at river mile 23, which also is the largest subpopulation on the river, is located on three large graywacke outcroppings in the middle of the channel. This place, known as the "Double Suck," is a popular spot for the rafters to stop and empty water from their rafts (Haggard and Halback 1985). Of the over 128,000 people who used the river in 1987, 105,765 were rafters (Allen, personal communication, 1988), so it is very likely that there is much contact with *P. ruthii*. However, the subpopulation located 0.2 mile upstream from the Ocoee No. 2 Powerhouse "...is highly visible from Hwy. 64 and probably receives more human disturbance than any other" on the river (Haggard and Halback 1985). The reason is that it is a popular location for spectators to observe kayakers and rafters going through "Rodeo Rapid."

Briefly mentioned in the previous discussion of Ocoee water management were the occasional releases from the Ocoee No. 2 Dam for the purpose of reducing silt buildup behind the dam. Although active land reclamation practices have reduced the present amount of erosion in the region, the silt load of the river continues to be a problem. Heavy erosion in the Copper Basin has led to the accumulation of enormous amounts of silt in the Ocoee River, which drains the basin. Large concentrations of silt apparently can cause much damage to dam gates and powerhouse machinery. In order to ensure continued proper functioning of the dam and powerhouse, water is released through the bottom of the dam as the need for doing so is determined. These releases flush great quantities of silt into the river, resulting in very large accumulations in the channel and on both banks of the river. These deposits, easily viewed from the highway at several locations, threaten to cover P. ruthii habitat and plants in places.

The poor water quality of the Ocoee River, a serious concern for P. ruthii, is the product of more than just the flushing of heavy amounts of silt. Runoff from the Copper Basin, which is located in the southeastern corner of Polk County and a small portion of northern Fannin County, Georgia, has had a deleterious effect on the Ocoee for well over 100 years (Maher 1973). Copper mining, which began in 1847, and the subsequent smelting of ore, combined to deforest and denude an area comprising over 50 square miles of the Copper Basin and adjoining territory. Logging to provide charcoal for the smelting process led to deforestation. Smelting of copper ores by an "open roasting" process introduced tremendous amounts of sulphur compounds into the air that eventually settled out onto the surrounding landscape. The resulting formation of acids killed the surrounding vegetation, which no longer had the protective cover of the forest. This brought about the denuded landscape (Killebrew and Safford 1874, Maher 1973). Acid runoff and leachings from mine tailings, as well as heavy silt loads from the erosion of highly acidified soils, all fed directly into the Ocoee.

High atmospheric emission of sulphur essentially ceased in 1904, but acid runoff and releases of wastewater remained a problem. This was partly because of the acquired low pH of the soils and partly because of the chemical industry that had grown up around the original mining operation (Maher 1973). Mining ceased in 1987, but release of acid and other pollutants into the Ocoee probably have not. White (1977) notes this problem in a communication with a TVA employee involved in monitoring water quality. One pH reading in the Ocoee, after an accidental spill in the Copper Basin, was as low as 1.6. When asked how often this occurred, the TVA employee replied "not infrequently." In addition, Maher (1973) notes the documented presence of high concentrations of iron salts and the heavy metals zinc and copper and the severe reduction of aquatic life in much of the Ocoee River between Copper Hill and Parksville Lake. There is little doubt that this history of poor water quality has had a negative impact on P. ruthii.

The proposed widening of the remainder of two-lane U.S. Route 64 along the Ocoee to a divided four-lane constitutes yet another threat to P. ruthii. A number of alternatives are being considered, but no final decision has been made. Some widening of the highway near the Ocoee No. 3 Powerhouse occurred several years ago and was accomplished by partially filling in the channel along the north bank (Shea 1988). Should new construction be performed in that manner along the 3-mile stretch where P. ruthii is found, both habitat and plants are very likely to be damaged or destroyed.

Conservation Efforts

Listing of *Pityopsis ruthii* as endangered by both the Federal government and the State of Tennessee is the major legal protection for the species. Federal recognition provides some protection from possible harmful actions involving Federal activities or federally funded projects. The range of *P. ruthii* is confined to U.S. Forest Service (USFS) land (Cherokee National Forest), and the Hiwassee and Ocoee Rivers are under the jurisdiction of TVA. Both of these Federal agencies are aware of the existence of the species and understand the importance of protecting it. In addition, the Hiwassee River is a designated State Scenic River under the Tennessee State Scenic Rivers Act (Chapter 540, Public Acts of 1968, as amended), and *P. ruthii* is afforded some additional protection under that statute.

The Tennessee Department of Environment and Conservation (TDEC), the Tennessee Wildlife Resources Agency (TWRA), TVA, and USFS have entered into a memorandum of understanding (MOU) regarding the management and maintenance of the scenic river corridor of the Hiwassee (Allen, personal communication, 1988). Any protection provided by this agreement would extend to *P. ruthii*. The Tennessee Rare Plant Protection and Conservation Act (Chapter 242, Public Acts of 1985), which is administered by TDEC, provides some protection, requiring permits for the removal of plants for scientific or commercial horticultural purposes and written permission of the land manager for removal for any purpose. Federal permits for removal would also be required. The physical location of *P. ruthii* is a *de facto* protection afforded the species on the Hiwassee River. Its occurrence on generally remote (or difficult to reach) federally owned lands along this river makes it of limited access to most people. Therefore, detrimental direct human contact is minimized.

Some management actions aimed at conservation have been suggested. Based on his assessment of the situation, White (1977) made a number of recommendations. They included yearly monitoring, sufficient releases of water (on the Hiwassee) from the Appalachia Dam during peak flooding seasons to mimic flooding conditions in the gorge prior to 1943, and the establishment of populations at suitable sites on the Hiwassee. Haggard and Halback (1985) suggested that water releases from the Appalachia Dam might be appropriate on the Hiwassee. They recommended hand-clearing of woody vegetation as well. They acknowledged, though, that the latter would consume a great deal of time and that both hand-clearing and scheduled releases of water would be very costly.

While neither water releases nor hand-clearing is likely to be feasible (or even warranted, at this point), someone apparently has taken it upon himself to implement the latter. Collins and Gunn (1986, 1987) noted the pruning of many small trees on a number of phyllite outcroppings on both sides of the Hiwassee River near McFarland. The frequency of and locations of the cuttings make it appear that they were not done in the course of some normal fishing or hiking activity. It is a reasonable assumption that the pruning was done to reduce perceived competition from woody vegetation in favor of *P. ruthii*.

PART II

RECOVERY

A. Objective

Ruth's golden aster (Pityopsis ruthii), with a known distribution limited to short stretches of two rivers in Polk County, Tennessee, is likely always to be a "rare" species. However, assuming that its current distribution corresponds to its total historic distribution and barring the discovery of any new populations on nearby rivers where potentially suitable habitat has been identified, certain criteria can be set forth and courses of action followed to make it possible for P. ruthii to be downgraded in status to threatened and to eventually be delisted.

The disparity in the sizes of the two known populations of P. ruthii and the dramatically different conditions under which each population exists necessitates a separate set of recovery goals for each river. Pityopsis ruthii, then, shall be considered for reclassification to threatened when either of the following situations occurs:

1. The Ocoee River population, under the criteria described in or to be established by implementation of Task 7, is deemed recovered and the rate of natural succession on the phyllite boulders on the Hiwassee River is determined to not be detrimental to the survival of P. ruthii;

   or

2. The Hiwassee River population, under the criteria described in or to be established by implementation of Task 6, is deemed recovered and Tasks 7.2, 7.3, 7.4, and 7.6 are accomplished for the Ocoee River population.

Pityopsis ruthii shall be considered recovered when the full set of recovery goals (Tasks 6 and 7) for each population is fulfilled.

B. Narrative Outline

1. Maintain formal agreements among the appropriate concerned agencies on the preservation of *Pityopsis ruthii*. Fortunately, both known populations of *P. ruthii* occur on lands that are in public ownership. The USFS (Cherokee National Forest) owns the phyllite boulders and adjacent slopes. The TVA is responsible for control of water flow regimes on both rivers. The State of Tennessee retains riparian rights. Because of: (1) the State scenic river status of the Hiwassee River, (2) the recreation management responsibilities on the Ocoee River, and (3) the State endangered species status for *P. ruthii*, the State also has responsibilities concerning the use of both rivers. This responsibility is coordinated by TDEC. The Service is involved because of the Federal endangered species listing of *P. ruthii*. Current agency interest in the species should be encouraged and strengthened. Decisions for its management should be arrived at based upon consultations among these agencies. Agreements on the preservation of the species should be reached by these agencies and formalized through the use of management plans, cooperative agreements, memoranda of understanding (MOU) or similar methods. These formal agreements are of paramount necessity if the long-term survival of *P. ruthii* is to be ensured. In 1986, TDEC, TWRA, TVA, and USFS entered into an MOU on the management of the Hiwassee River. The Hiwassee Scenic River Strategic Management Plan was completed in 1989. An MOU for the Ocoee River was signed by TDEC, TVA, and USFS in 1988. The Ocoee River General Management Plan was completed in 1988.

2. Maintain permanent plots. Several investigators report that the numbers of *Pityopsis ruthii* are declining, yet no data are provided to substantiate these claims. Reliable figures on the size of the populations on both rivers were first available in 1985. It will be necessary to maintain permanent plots on both rivers and to regularly monitor and analyze data to detect any trends in the population. Work currently being conducted jointly by TVA and TDEC involves the establishment of permanent plots on both rivers. These plots should be included in any long-term monitoring and additional similar ones established if deemed necessary. Monitoring should be conducted on an annual basis for a minimum of 5 years and once every 5 years thereafter until it can be determined that each population is self-sustaining.

3. Determine what is necessary for effective and successful achene dispersal, seed germination, and seedling establishment. The two known populations of *Pityopsis ruthii* currently exist under dramatically different circumstances, implying that attempts to recover either population will require a unique set of actions. Even though separate

methods will be employed for each effort, the plants themselves will behave in the same way. Before any specific recovery and management decisions can be made, basic knowledge of the species' life history and ecology must be acquired.

3.1 Study achene dispersal. The ability of a plant population to sustain itself partially depends upon the species' ability to distribute its seeds to new colonizable habitat (i.e., unoccupied suitable habitat) and to recolonize habitat already occupied. While it has been demonstrated that a low percentage of *P. ruthii* achenes contain viable seeds, it needs to be determined how the few viable seeds are dispersed to habitat which may be colonized. The role and influence of wind, rain, and flooding on the dispersal of achenes needs to be determined. The relationship between time of dispersal and success in establishment of new individuals needs to be determined.

3.2 Determine life history, seed germination, and seedling establishment requirements. Nothing is known about the conditions under which seeds of *P. ruthii* germinate in the wild. This point may be emphasized by realizing that even the time of year at which the seeds germinate is unknown. In order for proper and responsible decisions to be made regarding the possible management of the wild populations and/or the possible reintroduction of *P. ruthii* onto suitable unoccupied habitat, the optimum conditions for germination must be determined. Once germination for the species is better understood, the prerequisites for successful establishment and survival of seedlings should be determined. Studies focusing on germination and seedling establishment should include consideration of moisture, light, and soil requirements. This task may be combined successfully with Task 3.1.

3.3 Determine the role of interspecific and intraspecific competition. Intraspecific competition in *P. ruthii* should be evaluated in order to determine the highest densities at which individual plants can successfully grow with one another in good habitat. The role of competition between *P. ruthii* and encroaching woody vegetation, as well as competition from herbaceous associates growing on the phyllite boulders, should also be examined.

4. Determine what constitutes suitable habitat. The specific habitat requirements of *P. ruthii* are not known. Before prudent decisions can be made regarding management and recovery of the species, suitable habitat for *P. ruthii* must

be identifiable. It is widely believed that P. ruthii occurs exclusively on exposed precambrian phyllite rock. However, something more than the presence of bare phyllite boulders appears to be required for successful occupation by P. ruthii. Its recent discovery on graywacke, as well as numerous observations of apparently suitable, but unoccupied, habitat confirms this. Suitable habitat for P. ruthii is that which is capable of supporting and sustaining the species indefinitely under natural conditions. No attempts at managing current populations or colonies, or at establishing new ones in the wild, should be made without an understanding of what is suitable habitat. In making this determination, a number of aspects should be considered. The orientation of the strata (i.e., crevices and cracks between the lamiae) of the phyllite boulders in relation to the river flow and/or direction of prevailing winds should be studied. The roles of both flooding and drought in maintaining exposed boulders (including the reduction of competition) need to be examined. Once suitable habitat can be adequately described, then the total amount of suitable habitat, occupied or unoccupied, on both rivers, should be mapped. The completion of Tasks 3.1, 3.2, and 3.3 is not prerequisite to the completion of this task, but they should, at least, be underway before this task is begun.

5. Search for Pityopsis ruthii on other rivers. Ruth's golden aster should be searched for on rivers where potential habitat exists, but past searches have not been exhaustive. The stratigraphic band of phyllite that is exposed on the Hiwassee and Ocoee Rivers also occurs on the Tellico, Conasauga, and Jacks Rivers. It is reported that P. ruthii does not occur on either the Tellico or Conasauga, but all three rivers should be searched thoroughly for P. ruthii, with the exact areas searched and the results obtained being documented. Its presence or absence elsewhere would aid in defining suitable habitat and in confirming the actual range of the species.

6. Determine and implement for the Hiwassee River population the management necessary for long-term reproduction, maintenance, and vigor. Pityopsis ruthii's environment on the Hiwassee is the product of a variety of influences, such as the past and present manipulation of stream flow. Because the species now lives in an altered habitat, it may be necessary to employ active management techniques in order to ensure its survival. It should be determined what steps, if any, are required to provide for a self-sustaining population. Methods to increase current numbers of individuals also should be devised to hedge against dramatic unforeseeable loss of plants.

6.1 Determine and compare past and present stream flow regimes. Diversion of stream waters around that section of the Hiwassee where P. ruthii occurs undeniably holds significant implications for the plant communities associated with the river. Much has been said about those implications, particularly with regard to the lack of natural flooding and its relation to P. ruthii, but no definitive conclusions have been drawn. In order to adequately assess the effects of the current flow management regime upon P. ruthii, the present as well as the past (i.e., prior to 1943) "normal" flows must be determined and compared. The typical high-water mark and frequency of past (i.e., prior to 1943) flooding also should be determined and compared with the present flooding on the river. These studies should include such information as the past and present flow rates, the typical present and former widths of the channel during normal flow as well as during floods, and the known high-water marks at various points along the river. In addition to the usual sources for such data, old photographs of the river prior to and just after 1943 should be sought. They could provide valuable clues not available elsewhere. These photographs probably exist in the region since many people formerly lived along the river in various locations, such as at McFarland. Interviews with former residents would also be valuable.

6.2 Determine the nature and role of natural succession on the phyllite boulders. Pityopsis ruthii has been shown to compete poorly with other species in situations conducive to the growth of those species. This poor competitive ability apparently is the main reason for P. ruthii's restriction to such a harsh environment in nature. Because of the diversion of water from the natural channel and the subsequent reduction in flooding, which supposedly kept competing vegetation removed from the phyllite, some believe that natural succession now threatens to displace P. ruthii. While it is a possibility, very little data exist to support this claim. In order to accurately gauge the effects of natural succession upon P. ruthii, a long-term study to determine the actual rate of natural succession from the adjacent forests to the phyllite boulders must be undertaken. Such a study should provide information showing the age and distribution of woody plants occurring on the boulders in an effort to determine what was present prior to the diversion of flow. Old photographs again would be valuable for purposes of comparison. A study of soil buildup in the crevices of the phyllite should be made. The roles of flooding and drought on the rates and composition of natural succession should be determined.

6.3 Determine whether or not the population is self-sustaining. It is crucial to the survival of *P. ruthii* that its populations be self-sustaining. However, what constitutes a self-sustaining population for this species first must be defined. Once a definition is accepted, the appropriate measurements can be made. It may then be determined whether the population conforms to the definition. If the population is found not to be self-sustaining, implementation of Tasks 6.4 through 6.5 may adequately address the situation. However, if they fail to fully accomplish this, tasks and alternatives beyond the written recovery goals for this section may be necessary.

6.4 Establish *P. ruthii* on unoccupied suitable habitat. An ideal goal in the recovery of any species would be reoccupation of all or nearly all of the species' historic range. While *P. ruthii* apparently occupies its original range, there may be much suitable habitat within that range that presently is not supporting it. *Pityopsis ruthii* should be reintroduced to currently unoccupied suitable habitat until at least 80 percent of the total suitable habitat on the Hiwassee is supporting plants. An increase in numbers not only will ensure a more viable population, it also will provide a hedge against loss of individuals from other causes. Because of the variation in size of the phyllite boulders and the lack of knowledge about what plant densities can be supported under certain conditions, as well as for other reasons, the number of individuals to be reintroduced must be determined later. The knowledge and techniques learned in Tasks 3.1 and 3.2 should provide the ability to reintroduce and reestablish *P. ruthii* in suitable habitat. The completion of Task 4 will reveal the amount of unoccupied suitable habitat on the Hiwassee River.

6.5 Establish a cultivated population of plants descended from the Hiwassee River population and provide for long-term seed storage. A population in cultivation should be established to serve as a "back-up" for the natural population in the event of catastrophic loss. It may also be used to supply material in completing the above-mentioned tasks. A cultivated population would be especially useful in studies requiring manipulations of plants, such as studies of competition or response to flooding or drought, or any experiments in which natural populations should not be jeopardized. Any cultivated population, descended from either the Hiwassee River plants or the Ocoee River plants, should be maintained separately from the other to ensure no cross pollination or fertilization in order to maintain the genetic integrity of the two populations. Long-term seed storage also should be provided for as insurance against loss of both the wild and cultivated populations.

6.6 Determine feasibility and/or necessity of water releases and hand-clearing of phyllite boulders. Succession, unchecked because of the absence of historical natural flooding, is reported to be a serious threat to *P. ruthii* on the Hiwassee River. Because of the paucity of data, the actual extent of this threat is not known. To determine its extent, and whether or not it should be manipulated, is one of the goals of this recovery plan. If manipulation is indicated because natural succession is seen as a serious threat, then water releases and hand-clearing of vegetation are two methods that should be considered as part of a total management plan.

7. Determine and implement for the Ocoee River population the management necessary for long-term reproduction, maintenance, and vigor. Except for Tasks 7.1, 7.3, and 7.6, the following tasks should not be initiated before the completion of Tasks 2 through 5. See Task 6 for further discussion.

7.1 Study the relationship of the river to P. ruthii. The small size of the population on the Ocoee River probably can be attributed in part to the effects the river has had upon it. The nature of these effects, especially in recent years, and the degree to which they have influenced the population, are not known. Past and present management of the river's flow for power generation and white-water recreation, with its accompanying fluctuating water levels, need to be examined, and how it has impacted *P. ruthii* needs to be determined. The past decline of water quality as a combined result of leachings from mine tailings, acid precipitation, effluent of industrial wastewater, and severe erosion of acidified soils also must be investigated and its effects upon *P. ruthii* gauged. Because present water management and water quality do not begin to approximate what would occur under natural conditions, the present influence of the Ocoee on the species should be carefully studied. Existing threats to *P. ruthii* should be determined, and methods should be devised to eliminate them. Because of the complexity and magnitude of the water quality and management problems, implementation of any remedial steps will require the cooperation of the appropriate State and Federal agencies as well as private organizations whose responsibilities and interests include overseeing such matters.

7.2 Determine impacts of river recreational users and implement required management actions. Increasing numbers of rafters, kayakers, and canoers are taking advantage of the white-water recreation opportunities afforded by the Ocoee River. With annual user numbers now well over 100,000, there exists greater opportunity for detrimental contact with *P. ruthii*. In addition to the active "river user," the number of spectators of the white-water sports is increasing. Although white-water enthusiasts have rights to the use of the river, impacts to *P. ruthii* must be kept to insignificant levels. Management techniques to accomplish this must be determined and implemented. The use of signs, the creation of "restricted zones" where *P. ruthii* occurs, the designation of boat take-out points, and the erection of protective fencing all are management tools whose use should be considered, and implemented, if appropriate.

7.3 Ensure that highway construction will not damage or destroy plants or suitable habitat. Habitat for *P. ruthii* on the Ocoee River is very limited. What likely was a significant amount of habitat already has been destroyed in past road construction and other projects. Because of the very small size of the Ocoee population, it is critical that no more plants or habitat be destroyed through highway construction. The Service, USFS, TVA, TDEC, Tennessee Department of Transportation, and other interested agencies and organizations should consult with each other regarding planning that would avoid damaging the species or its habitat.

7.4 Determine whether the population is self-sustaining. See Task 6.3. If the population is determined to not be self-sustaining, then it is hoped that implementation of the following Task 7.5 will address the situation adequately. However, if it fails to fully accomplish this, tasks and alternatives beyond the recovery goals for this section may be necessary.

7.5 Establish *P. ruthii* on unoccupied suitable habitat. See Task 6.4. *Pityopsis ruthii* should be reintroduced and reestablished on all suitable unoccupied habitat until essentially all of the total suitable habitat is supporting plants.

7.6 Establish a cultivated population of plants descended from the Ocoee River population and provide for long-term seed storage. See Task 6.5 for further discussion.

C. Literature Cited

Bowers, F. D. 1972a. The existence of *Heterotheca ruthii*. (Compositae). Castanea 37:130-132.

------. 1972b. A biosystematic study of *Heterotheca* section *Pityopsis*. Ph.D. Dissertation. University of Tennessee, Knoxville, TN.

Collins, J. L. 1987. Unpublished research. Tennessee Valley Authority, Office of Natural Resources, Norris, TN.

Collins, J. L., and S. C. Gunn. 1986. Unpublished research. Tennessee Valley Authority, Office of Natural Resources, Norris, TN, and Tennessee Department of Environment and Conservation, Division of Ecological Services, Nashville, TN.

Cronquist, A. 1980. Vascular Flora of the Southeastern United States: Volume 1 - *Asteraceae*. The University of North Carolina Press. Chapel Hill, NC.

Dress, W. J. 1953. A revision of the genus *Chrysopsis* in Eastern North America. Ph.D. Dissertation. Cornell University, Ithaca, NY.

Farmer, R. E., Jr. 1977. Seed propagation of *Heterotheca ruthii*. Castanea 42:146-149.

Fernald, M. L. 1942. The seventh century of additions to the flora of Virginia: *Chrysopsis graminifolia* and its allies in Virginia and the Carolinas. Rhodora 44:464-473.

Gattinger, A. 1901. The Flora of Tennessee and a Philosophy of Botany. Tennessee Bureau of Agriculture.

Haggard, D., and M. Halback. 1985. *Heterotheca ruthii* (Small) Harms. Unpublished report to Tennessee Department of Environment and Conservation, Division of Ecological Services, Nashville, TN.

Hardeman, W. D. 1966. Geologic Map of Tennessee, East Central Sheet. Tennessee Department of Environment and Conservation, Division of Geology, Nashville, TN.

Harms, V. L. 1969. A preliminary conspectus of *Heterotheca* section *Pityopsis* (Compositae). Castanea 34:402-409.

Killebrew, J. B., and J. M. Safford. 1874. Introduction to the Resources of Tennessee. Tennessee Bureau of Agriculture. Nashville, TN. Pp. 205-252.

Kral, R. 1983. A Report on Some Rare, Threatened or Endangered Forest-related Vascular Plants of the South: Aquifoliaceae through Asteraceae and Glossary. Technical Publication R8-TP2. USDA. Forest Service. Vol. 2. Pp. 1183-1186.

Loney, J. 1984. The Ocoee River controversy: arriving at a solution. In National River Recreation Symposium Proceedings. J. S. Popadic, Ed. Louisiana State University School of Landscape Architecture, Baton Rouge, LA. Pp. 122-135.

Maher, S. W. 1973. Field Trip Guide: Ocoee River Gorge and Copper Basin. International Geobotany Conference. University of Tennessee, Knoxville, TN.

Semple, J. C. 1977. Cytotaxonomy of Chrysopsis and Heterotheca Compositae-Asteraceae): a new interpretation of phylogeny. Can. J. Bot. 55: 2503-2513.

Semple, J. C., V. C. Blok, and P. Heiman. 1980. Morphological, anatomical, habit and habitat differences among the golden aster genera Chrysopsis, Heterotheca, and Pityopsis (Compositae-Asteraceae). Can. J. Bot. 58: 147-163.

Semple, J. C., and F. D. Bowers. 1985. A Revision of the Golden Aster Genus Pityopsis Nutt. (Compositae: Asteraceae). University of Waterloo Biological Series No. 29. Department of Biology, University of Waterloo. Waterloo, Ontario, Canada.

Shea, A. 1988. Tennessee Department of Transportation, Division of Environmental Planning, Nashville, TN. Personal communication.

Shinners, L. H. 1951. The north Texas species of Heterotheca including Chrysopsis (Compositae). Field and Lab. 19:66-71.

Small, J. K. 1897. Studies in the botany of the Southeastern United States: XII. Bull. Torr. Bot. Club 24(2):493.

------. 1933. Manual of the Southeastern Flora. Published by the author. New York, NY.

U.S. Fish and Wildlife Service. 1985. Endangered and threatened wildlife and plants; determination of Pityopsis ruthii (Ruth's golden aster) to be an endangered species. Federal Register 50(138):29341-29344.

White, A. J. 1977. An autecological study of the endangered species, Heterotheca ruthii (Small) Harms. M.S. Thesis. University of Tennessee, Knoxville, TN.

------. 1978. Range extension of the proposed endangered plant, Heterotheca ruthii (Compositae). Castanea 43(4):263.

Wofford, B. E., and D. K. Smith. 1980. Status report on Heterotheca ruthii (Small) Harms to U.S. Department of the Interior, Fish and Wildlife Service, Region 4. Department of Botany, University of Tennessee, Knoxville, TN.

PART III

IMPLEMENTATION SCHEDULE

Priorities in column one of the following Implementation Schedule are assigned as follows:

1. Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

2. Priority 2 - An action that must be taken to prevent a significant decline in species population, habitat quality, or some other significant negative impact short of extinction.

3. Priority 3 - All other actions necessary to meet the recovery objective.

Key to Acronyms Used in This Implementation Schedule

CPC - Center for Plant Conservation
FHWA - Federal Highway Administration
FWE - Fish and Wildlife Enhancement (Division of U.S. Fish and Wildlife Service)
FWS - U.S. Fish and Wildlife Service
LE - Law Enforcement (Division of U.S. Fish and Wildlife Service)
TDEC - Tennessee Department of Environment and Conservation
TDOT - Tennessee Department of Transportation
USFS - U.S. Forest Service

IMPLEMENTATION SCHEDULE

PRIORITY #	TASK #	TASK DESCRIPTION	TASK DURATION (Years)	RESPONSIBLE PARTY: FWS Region	RESPONSIBLE PARTY: FWS Division	RESPONSIBLE PARTY: Other	COST ESTIMATES ($000'S): FY 1993	FY 1994	FY 1995	COMMENTS
1	3.1	Study achene dispersal.	3 years	4	FWE	TDEC TVA	2.0	2.0	2.0	
1	3.2	Determine seed germination/seedling establishment requirements.	3 years	4	FWE	TDEC TVA	8.0	4.0	2.0	Cost can be reduced by combining with Task 3.1.
1	3.3	Determine role of competition.	3 years	4	FWE	TDEC TVA	5.0	1.0	1.0	
1	4	Define habitat.	2 years	4	FWE	TDEC TVA	3.0	3.0		
1	6.2	Examine succession on boulders.	5 years	4	FWE	TDEC TVA	5.0	2.0	2.0	Cost can be reduced by combining with Task 3.3.
1	6.3	Determine if Hiwassee population is self-sustaining.	4 years	4	FWE	TDEC TVA	4.0	2.0	2.0	
1	6.6	Determine management requirements for Hiwassee population.	5 years	4	FWE	TDEC TVA	10.0	3.0	3.0	

IMPLEMENTATION SCHEDULE

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (Years)	RESPONSIBLE PARTY			COST ESTIMATES ($000'S)			COMMENTS
				FWS						
				Region	Division	Other	FY 1993	FY 1994	FY 1995	
2	6.1	Examine Hiwassee flow regimes.	1 year	4	FWE	TVA TDEC	10.0			
2	6.4	Establish additional colonies on Hiwassee.	3 years	4	FWE	TVA TDEC CPC	6.0	1.0	1.0	
2	6.5	Establish cultivated population with Hiwassee plants.	1 year	4	FWE	TVA CPC	5.0			Completed in FY 1990.
3	5	Search for new populations.	1 year	4	FWE	TDEC TVA	6.0			

IMPLEMENTATION SCHEDULE

PRIOR-ITY #	TASK #	TASK DESCRIPTION	TASK DURATION (Years)	RESPONSIBLE PARTY: FWS Region	RESPONSIBLE PARTY: FWS Division	RESPONSIBLE PARTY: Other	COST ESTIMATES ($000'S): FY 1993	COST ESTIMATES ($000'S): FY 1994	COST ESTIMATES ($000'S): FY 1995	COMMENTS
1	7.1	Study species/ River interactions on the Ocoee.	3 years	4	FWE	TVA TDEC	8.0	3.0	3.0	
1	7.2	Determine recreation impacts on the Ocoee.	3 years	4	FWE	TVA TDEC	8.0	8.0	8.0	
1	7.3	Ensure highway construction doesn't affect Ocoee population.	Ongoing	4	FWE	TDEC TVA FHWA TDOT	None	None	None	
1	7.5	Establish colonies on suitable Ocoee habitat.	3 years	4	FWE	TDEC TVA CPC	6.0	1.0	1.0	
1	7.6	Establish cultivated populations with Ocoee plants.	1 year	4	FWE	TDEC TVA CPC	5.0			Accomplished in FY 1991.
2	1	Formalize agreements.	1 year	4	FWE LE	TDEC USFS TVA	1.5			Completed.
2	2	Establish plots.	Ongoing	4	FWE	TDEC USFS TVA	5.0	2.0	2.0	

PART IV

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